Monitoring Riparian and Semi-Arid Upland Vegetation Using Vegetation and Water Indices from the MODIS Satellite Sensor

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INTRODUCTION

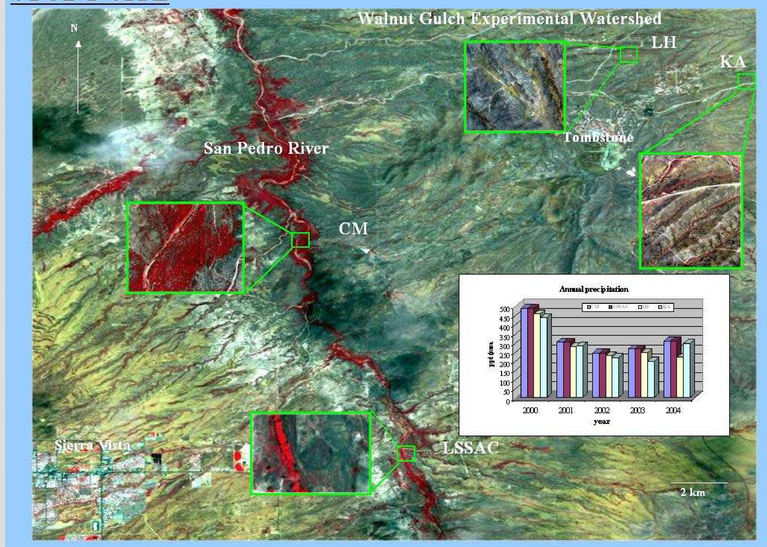
- Deriving vegetation water status from remotely-sensed data has important applications in drought monitoring, water balance studies, and fire risk assessment.
- The San Pedro National Conservation Area, AZ contains both riparian and semiarid upland vegetation communities which are tightly coupled to water availability and susceptible to environmental disturbance.
- Remote sensing provides enhanced monitoring capabilities with continuous spatial and temporal measurements over these fragile ecosystems.
- This provides opportunities to develop methodologies for effective resource management, early warning detection of environmental changes, and evaluation of vegetation response to climate and human forcings.

OBJECTIVES

We analyzed Terra- Moderate Resolution Imaging Spectroradiometer (MODIS) products as indicators of vegetation activity in order to,

- characterize and quantify the seasonal dynamics and inter-annual variations associated with the major vegetation types in the Walnut Gulch Experimental Watershed and San Pedro National Conservation Area, AZ,
- compare vegetation greenness and water status with evapotranspiration from Eddy flux tower,
- Evaluate land cover conditions through a 5-year, ongoing, drought period.

STUDY SITE



MODIS VEGETATION AND WATER INDICES

- Seasonal and interannual variations in vegetation phenology and canopy water status were investigated with 5 years of continuous, 16-day composited MODIS enhanced vegetation index (EVI) and land surface water index (LSWI) data,

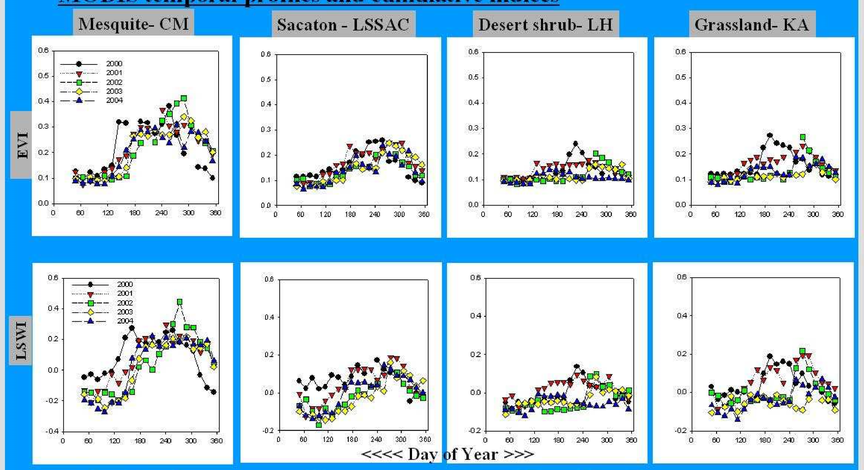
$$EVI = 2.5 * \frac{\rho_{NIR} - \rho_{red}}{1 + \rho_{NIR} + 6 * \rho_{red} - 7.5 * \rho_{blue}} \qquad LSWI = \frac{\rho_{NIR} - \rho_{SWIR\ (2130\ nm)}}{\rho_{NIR} + \rho_{SWIR\ (2130\ nm)}}$$

- Data were extracted across a highly diverse set of vegetation cover types, which included mesquite bosque, sacaton grass, creosotebush desert shrub, and semiarid grassland.
- EVI provided a measure of chlorophyll (greenness) while LSWI provides a measure of vegetation water

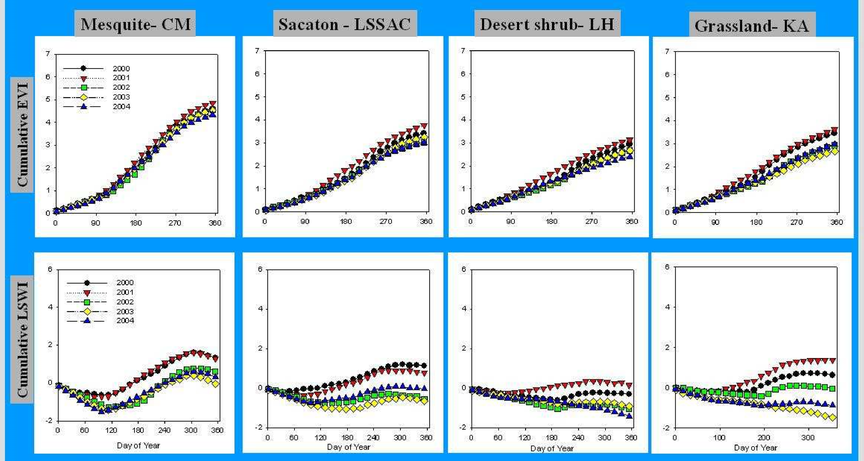
RESULTS

- The MODIS seasonal profiles depict vegetation shifts in phenology associated with land cover (physiognomy) and species types.
- The MODIS data show significant inter-annual variations from 2000 to 2004 with a general decline in vegetation productivity through this drought period.
- The MODIS vegetation index - water index scatter-plots depict large differences in water use patterns and efficiencies among riparian and upland vegetation types
- MODIS 'greenness' and water indices correlated well with evapotranspiration data from eddy flux towers but with only minor differences in their relationships.

MODIS temporal profiles and cumulative indices

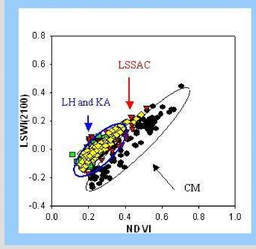


• The riparian communities green-up first, followed by the sacaton grass and then the upland areas.

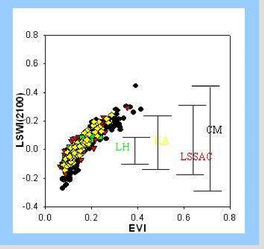


• The 'cumulative sum' indices show larger inter-annual variations over the upland vegetation types (LH, KA). The water index was very sensitive to climate variation with 2002-2004 being drier years relative to 2000 & 2001.

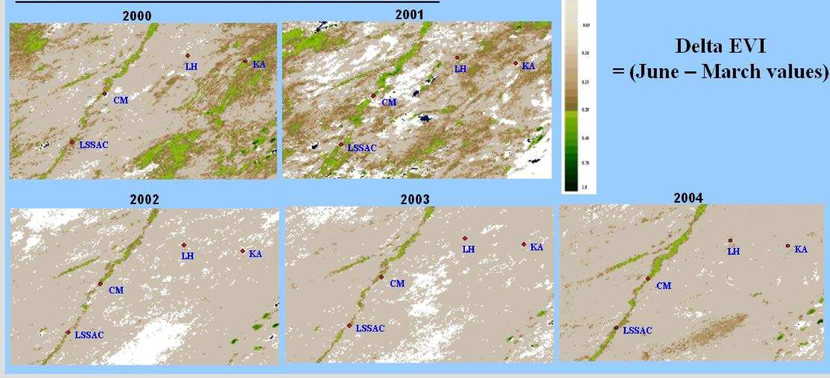
Vegetation index – water index scatter-plots



The location of each site can be identified in the scatter-plot and the range of LSWI showed different water use characteristics between riparian and upland vegetation

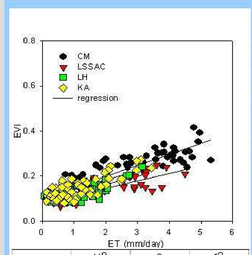


EVI differences between June and March



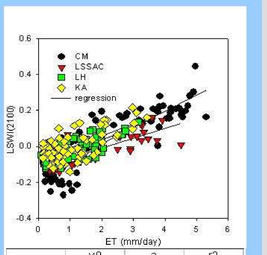
Delta EVI = (June – March values)

Evapotranspiration with EVI and LSWI



	y0	a	r2
CM	0.1010	0.0490	0.7900
LSSAC	0.0770	0.0340	0.6800
LH	0.0910	0.0360	0.6200
KA	0.0940	0.0440	0.6400

- Both EVI and LSWI show similar capability to predict evapotranspiration with only minor differences.
- A single (global) relationship is apparent in EVI – ET across land cover types



	y0	a	r2
CM	-0.1660	0.0900	0.7300
LSSAC	-0.1180	0.0540	0.6300
LH	-0.0800	0.0590	0.5400
KA	-0.0710	0.0650	0.4800

- y^0 and 'a' denote intercept and slope respectively

CONCLUSIONS

The MODIS temporal profiles provided valuable information on variations in vegetation phenology and water status, both seasonally and interannually across a drought period.

- The water indices appeared more useful in extracting vegetation water status, and in drought detection and water sustainability studies.
- The 'greenness' and water indices both behaved similarly in ET studies but when used in combination, they provided measures of water use efficiency and improved upon the derivation of phenology metrics over the various land cover conditions.

Future Work is needed to:

- Quantify changes in vegetation, carbon and water fluxes, and chlorophyll content,
- Validate the use of 'greenness' and water indices with accurate measurement of vegetation water and chlorophyll contents.
- Scaling the biophysical relationships for region-wide water balance, stress, and drought detection studies.

TBRS Terrestrial Biophysics & Remote Sensing Lab — University of Arizona